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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H05K 13/08 — A1

(11) International Publication Number: WO 99/44409

(43) International Publication Date: 2 September 1999 (02.09.99)

(21) International Application Number: PCT/JP99/00904

(22) International Filing Date: 26 February 1999 (26.02.99)

(30) Priority Data:

10/47865	27 February 1998 (27.02.98)	JP
10/333914	25 November 1998 (25.11.98)	JP

(81) Designated States: CN, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

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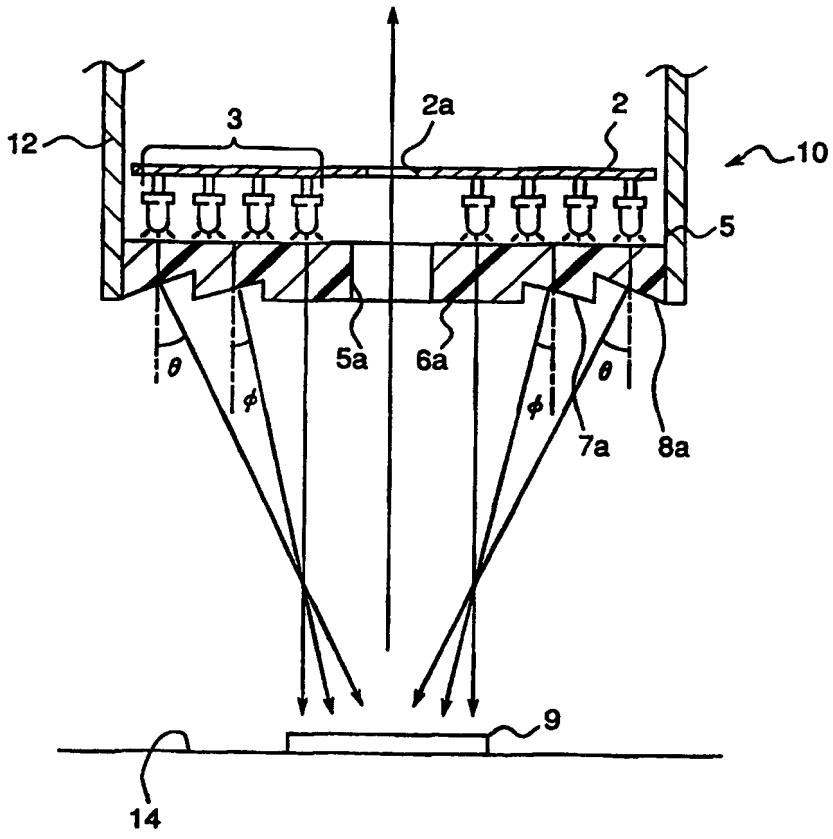
(54) Title: ELECTRONIC COMPONENT MOUNTING APPARATUS

(57) Abstract

The electronic component mounting apparatus (1) comprises, as a device for illuminating a mark (9) on a printed circuit board (14) for recognition, an illumination device (10) with a light path adjustable member (5). This light path adjustable member (5) is disposed between the illumination source unit (2) and the object (9) to be illuminated. At least either the light incidence side or emission side of the light path adjustable member (5) is divided into a plurality of subareas (6, 7, 8) each having a different index of refraction. Each of the subareas (6, 7, 8) emits light at respective different index of refraction. The emitted light can cbe collected on a specific area containing the object (9), and appropriate illumination light can thus be emitted to the object (9).



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DESCRIPTION

ELECTRONIC COMPONENT MOUNTING APPARATUS

TECHNICAL FIELD

The present invention relates to an electronic component mounting apparatus for recognizing a mark provided at a specific location on a printed circuit board, and mounting an electronic component on the printed circuit board.

BACKGROUND ART

As commonly known, an electronic component mounting apparatus for mounting electronic components on a printed circuit board, recognizes a mark on the printed circuit board and positions the electronic or other component to be mounted during the mounting operation, for example, using a CCD camera or sensors. An illumination device is used, during object recognition, to emit light onto or near the object and thus illuminate the object.

An example of a conventional illumination device is shown in Fig.12. This illumination device 50 has a CCD camera 51 for recognizing an object 59 at the top center of a case 57, and an illumination source unit 52 comprising a

plurality of light sources 53 (such as light bulbs or LEDs) below the CCD camera 51. An aperture 52a is formed in the middle of the illumination source unit 52 to capture light reflected from the object.

With an illumination device 50 according to this conventional arrangement, a portion of the light emitted from each of the light sources 53 in the illumination source unit 52 irradiates the object 59, and the light reflected therefrom passes the aperture 52a and is captured by the CCD camera 51, as indicated by solid arrows in Fig.12. It should be noted that with this conventional illumination device 50, all of the light sources 53 in the illumination source unit 52 are turned on in use, so that light is uniformly emitted to the object 59.

Recently, various materials having each surface conditions are used for the electronic components and a mark on the printed circuit board as an object, and various surface treatments are performed. Thus, various improvements have also been made to the illumination device so that it is possible to recognize satisfactorily a variety of objects having various surface conditions.

Fig.13 shows an illumination source unit 62 in an illumination device according to another conventional arrangement. In this illumination source unit 62, numerous light sources 63 are arranged in a plurality of circles of

different diameters (that is, concentrically) such that light sources 63 on the same circle form a light source group, and quantity of light can be adjusted by each light source group. The quantity of light by the sources 63 in each unit circle is then adjusted according to the surface condition of the object so that the optimum illumination is provided for object recognition.

Even with an illumination device unit having an illumination source unit 62 as described above, however, if the quantity of light by the sources 63 chosen to be turned on is not sufficient, the illumination required for object recognition cannot be achieved, and the recognition rate may drop or detection errors may occur.

Furthermore, because all of the light sources 63 are disposed on the same plane in the same direction, the illumination angle of the light becomes dependent on the directivity of the light sources 63, and it is difficult to achieve sufficient brightness at a desired illumination angle. Because of this, it is conceivable to increase brightness, for example, by increasing the number of light sources 63 or increasing the quantity of light by each light source 63. This, however, can result in such problems as an increase in current consumption, a drop in the stability of the brightness as a result of heat emitted by the light source, and shortened service life in the light sources 63.

It is also possible to vary the installation angle of the light sources 63 so that the illumination angle can be set as desired. In this case, however, the construction of the apparatus becomes complicated and large, causing an increase in cost. Furthermore, adjusting the illumination angle is, in practice, complicated and not easy, and therefore tends not to be practical.

As described above, it is particularly difficult with an electronic component mounting apparatus having a conventional illumination device to emit suitable illumination to recognition objects with various surface conditions and thereby achieve object recognition satisfactorily.

DISCLOSURE OF INVENTION

In view of the technical problems as described above, an object of the present invention is to provide an electronic component mounting apparatus for performing reliable object recognition and mounting tasks by comprising an illumination source unit for emitting suitable illumination light to an object by means of a simple configuration, without increasing the number of light sources or the quantity of light of each light source.

According to the present invention, there is provided an electronic component mounting apparatus for

recognizing a mark provided at a specific location on a printed circuit board and mounting an electronic component on said printed circuit board, comprising an illumination device having a light path adjustable member, as a device for illuminating said mark for object recognition. At least either the light incidence side or emission side of said light path adjustable member is divided into a plurality of subareas with respective different index of refraction, wherein the light path adjustable member is disposed between an object to be illuminated by the emitted light and an illumination source unit for emitting light in the direction of said object. The light path adjustable member gathers light emitted therefrom on a specific area including said object by emitting light incident thereto from the illumination source unit from each of the subareas at the respective different index of refraction.

Preferably, at least either the light incidence side or emission side of said light path adjustable member may be divided into a plurality of belt-shaped subarea forming concentric circles, and the index of refraction on the emission side of each belt-shaped subarea may decreases as it is closer to the center. Also preferably, the light-transmitting surface of a plurality of the subareas in the light path adjustable member may be a segment of a curved surface, the curvature of which differs in each subarea.

Both the light incidence side and emission side of the light path adjustable member may be divided into a plurality of subareas, each having a different index of refraction, and both light-transmitting surfaces of each subarea are segments of a convex curved surface. The light-emitting surface of each subarea may be formed in the shape of a ground glass surface.

Further, the illumination source unit may comprise a plurality of light sources directed toward each subarea of the light path adjustable member, and said light sources can be selectively turned on. Each of the light sources may emit light with a color complementary to a color of the printed circuit board or mark thereon, and may comprise a plurality of light-emitting elements of different colors.

A first advantage of the electronic component mounting apparatus according to the invention is that the mounting apparatus can emit appropriate illumination light to an object, and thus accomplish object recognition and mounting operations satisfactorily, because the apparatus comprises, as a device for recognizing a mark on a printed circuit board, an illumination device with a light path adjustable member disposed between an illumination source unit for illuminating an object and the object to which the illumination is to be emitted, where at least the light

incidence side or irradiation side of the light path adjustable member is divided into a plurality of subareas each having a different index of refraction, and thus collects the emitted light on a specific area containing the object by emitting light incident from the illumination source unit at different indices of refraction.

Further, a second advantage of the electronic component mounting apparatus according to the invention is that illumination light passing each subarea can be gathered toward the center of the irradiated light, because at least the light incidence side or irradiation side of the light path adjustable member is divided into a plurality of subareas forming concentric circles, and the index of refraction on the irradiation side of each subarea band decreases as it is closer to the center.

Moreover, a third advantage of the electronic component mounting apparatus according to the invention is that light from the illumination source unit is refracted and directed toward the object at all points on each light-transmitting surface, and can therefore be precisely gathered on the object because the light-transmitting surface of the plural subareas in the light path adjustable member is a segment of a curved surface, the curvature of which differs in each subarea.

Yet further, a fourth advantage of the electronic

component mounting apparatus according to the invention is that a significant light-gathering effect can be achieved using refraction on both sides of the light path adjustable member because both the light incidence side and irradiation side of the light path adjustable member are divided into a plurality of subareas, each having a different index of refraction, and both light-transmitting surfaces of each subarea are segments of a convex curved surface.

Yet further, a fifth advantage of the electronic component mounting apparatus according to the invention is that light from the illumination source unit can be diffused and emitted to a specific area including an object, without dropping the light gathering effect of each light-transmitting surface with a specific index of refraction, because the light-emitting surface of each subarea is formed in the shape of a ground glass surface.

Yet further, a sixth advantage of the electronic component mounting apparatus according to the invention is that when the light sources of the illumination source unit are selectively turned on so as to emphasize the contrast between a mark and the printed circuit board forming the background thereto, an even clearer image can be obtained, and the accuracy of mark recognition by the apparatus can be improved, because the illumination source unit comprises a plurality of light sources directed toward each

subarea of the light path adjustable member, and said light sources can be selectively turned on.

Yet further, a seventh advantage of the electronic component mounting apparatus according to the invention is that the overall illumination source unit can emit the illumination light adjusted to the color complementary to the color of the printed circuit board or mark to the printed circuit board and mark, contrast between the mark and printed circuit board can thereby be enhanced, an even clearer image can be obtained, and the accuracy of mark recognition by the apparatus can be improved, because each light source can emit light of a color complementary to a color of the printed circuit board or mark thereon.

Yet further, a eighth advantage of the electronic component mounting apparatus according to the invention is that each light source can internally produce the color complementary to the color of the printed circuit board or mark, illumination of this complementary color can be directly emitted from each light source, and illumination light free of color irregularities can be emitted, because each light source comprises a plurality of light-emitting elements of different colors. As a result, contrast between a mark and printed circuit board can be reliably enhanced suitably according to the surface condition of any printed circuit board or mark. Furthermore, it is not necessary to

provide separate light sources for each color, for example, red, green, and blue, in an illumination source unit comprising such light sources, the number of light sources can therefore reduced, and reduction in the size and weight of the illumination source unit can thereby be promoted.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a schematic oblique view showing the overall configuration of a mounting apparatus according to a preferred embodiment of the present invention.

Fig.2 is a vertical descriptive section view of the illumination device provided in the above mounting apparatus.

Fig.3 is an oblique view of the illumination device.

Fig.4 is a plan view of the illumination source unit in the illumination device.

Fig.5A is a plan view of the light path adjustable member in the illumination device, Fig.5B is an oblique view of the light path adjustable member, and Fig.5C is a section view through line X-X in Fig.5A.

Fig.6 is a section view showing the gathering of light on an object during illumination by the illumination device.

Fig.7A is a schematic view of an illumination source unit in which light sources are selectively turned on

according to the mirror surface condition of a mark, and Fig.7B is a schematic view of an illumination source unit in which light sources are selectively turned on according to the mirror surface condition of a printed circuit board.

Fig.8 is a partial section view of a light path adjustable member comprising in each subarea a curved light-transmitting surface.

Fig.9 is a section view of a light path adjustable member divided on both sides thereof into a plurality of subareas.

Fig.10 is a plan view of an illumination source unit according to an alternative embodiment of the present invention.

Fig.11 is a circuit diagram of an illumination circuit according to a further alternative embodiment of the present invention.

Fig.12 is a section view showing the gathering of light on an object during illumination by a conventional illumination device.

Fig.13 is a plan view of an illumination source unit in a further conventional illumination device.

BEST MODE FOR CARRYING OUT THE INVENTION

A preferred embodiment of the present invention is described in detail below with reference to the

accompanying figures.

Fig.1 is a schematic oblique view of the overall configuration of an electronic component mounting apparatus 1 according to a preferred embodiment of the present invention. This electronic component mounting apparatus 1 recognizes, for example, a mark 9 for positioning provided at a specific position on a printed circuit board 14, and mounts an electronic component on the printed circuit board 14. The mounting apparatus 1 comprises an illumination device 10 for illuminating the mark 9 during mark recognition operation. It should be noted that the surface condition of the object to be recognized (that is, the mark 9), may be variously comprised. For example, the surface may be coated with solder (a so-called solder mark).

This illumination device 10 is included in a head unit 15 together with a CCD camera (see Fig.2) for imaging the mark 9. This head unit 15 is controlled by an x-axis drive unit 17, and y-axis drive units 18A and 18B for moving the x-axis drive unit 17 in the y-axis direction, which are part of an two-axis (x-y) robot. The illumination device 10 can thus move freely above the printed circuit board 14 as the head unit 15 is driven.

Fig.2 and Fig.3 are a vertical cross section and a partially exploded oblique view, respectively, showing the

overall configuration of the illumination device 10. With this illumination device 10, a CCD camera 11 for object recognition is provided at the top center of a cylindrical case 12, and below the CCD camera 11, an illumination source unit 2 is disposed with a plurality of light sources 3 on a base plate 4. Opposite the illumination source unit 2 and on the emission side thereof, a light path adjustable plate 5 for adjusting the path of light emitted from the light sources 3 is affixed at the lower part of the case 12 using bolt 13. In this preferred embodiment, the light path adjustable plate 5 is disposed proximally to the illumination source unit 2 so that light from the light sources 3 can be efficiently picked up. Apertures 4a and 5a for passing light reflected from a mark (not shown in the Figs.), which is provided on the printed circuit board as the object to be illuminated by the illumination light during the mounting operation, are formed in the light path adjustable plate 5 and the base plate 4 of the illumination source unit 2. It should be noted that some of the light sources 3 are omitted in Fig.3 to avoid making the figure too complicated.

With an illumination device 10 thus comprised, a portion of the light from each of the light sources 3 in the illumination source unit 2 irradiates the printed circuit board, and the reflected light passes the apertures 4a and 5a and is captured by the CCD camera 11. This CCD

camera 11 is connected to an image recognition apparatus 16. Reflected light from the object captured by the CCD camera 11 is passed to the image recognition apparatus 16 as an electrical signal, and is recognized as an image as the result of a specific image recognition process.

An arrangement of a plurality of the light sources 3 in the illumination source unit 2 is shown in Fig.4. In this preferred embodiment, for example, white LEDs can be used as the light sources 3. As will be known from the figure, these light sources 3 are arranged on a circular base plate 4 in a plurality of the circles with different diameters (that is, in concentric circles), thus forming four light source groups 3A, 3B, 3C, and 3D. The light source group 3A on the inside-most circumference is disposed around the aperture 4a in the center of the base plate 4, and the light source group 3D on the outside-most circumference is disposed along the outside perimeter of the base plate 4. The light sources 3 comprising these light source groups 3A to 3D are disposed perpendicularly to the base plate 4 and directed toward the light path adjustable plate 5 mounted below the illumination source unit 2.

It should be noted that the light sources 3 are arranged in concentric circles in this illumination source unit 2 so that illumination light with uniform illuminance is emitted from all directions with respect to the optical axis

of the CCD camera 11. However, any arrangement can be used insofar as illumination of uniform illuminance can be obtained.

A light path adjustable plate 5 as used in this preferred embodiment is shown in Fig.5A to Fig.5C. Fig.5A to Fig.5C are, respectively, a plan view, oblique view, and section view of the light path adjustable plate 5. This light path adjustable plate 5 is formed in a disk shape from a transparent acrylic resin. The emission side of the light path adjustable plate 5 is divided into three belt-shaped subareas 6, 7, and 8 forming concentric circles, and a light-transmitting surface 6a, 7a, and 8a, each forming a different angle to the planar direction of the light path adjustable plate 5, is formed in each of these belt-shaped subareas 6, 7, and 8. An opening 5b is also provided in the light path adjustable plate 5 from the circumferential surface thereof toward the center of the light path adjustable plate 5 for accepting a bolt 13 (see Fig.2) when the light path adjustable plate 5 is mounted to the case 12.

The light-transmitting surface 6a of the belt-shaped subarea 6 at the inside-most circumference on the emission side of the light path adjustable plate 5 is a surface substantially parallel to the planar direction of the light path adjustable plate 5, while the light-transmitting surfaces 7a and 8a of the belt-shaped subareas 7 and 8

positioned on the outside of the belt-shaped subarea 6 are inclined at a specific angle to the planar direction of this light path adjustable plate 5. In this preferred embodiment, the angle of inclination of the light-transmitting surface 7a in the belt-shaped subarea 7 is smaller than the angle of inclination of the light-transmitting surface 8a in the outside belt-shaped subarea 8.

It should be noted that in this preferred embodiment, the maximum depth and maximum width of the belt-shaped subareas 7 and 8 other than the belt-shaped subarea 6 at the inside-most circumference are set to 1 mm and approximately 3 mm, respectively. Furthermore, while a transparent acrylic resin is used for the light path adjustable plate 5, the invention shall not be so limited, and a light path adjustable plate made, for example, from a transparent or semi-transparent glass or plastic can be alternatively used.

The light-gathering action of the light path adjustable plate 5 in the above-noted illumination device 10 is described next below with reference to Fig.6.

As shown in Fig.6, when all of the light sources 3 in the illumination source unit 2 are turned on, light incident from right above subarea 6C at the outside-most position of the light path adjustable plate 5 is refracted angle at light-transmitting surface 6c as indicated by the

solid arrows with this illumination device 10. The light incident from right above subarea 6B is refracted angle at light-transmitting surface 6b. As described above, because the angle of inclination of light-transmitting surface 6b is smaller than that of light-transmitting surface 6c to the outside thereof in this light path adjustable plate 5, the angle of refraction of this light-transmitting surface 6b is smaller than the angle of refraction of light-transmitting surface 6c.

Furthermore, light incident from right above subarea 6A at the inside-most circumference of the light path adjustable plate 5 passes the light path adjustable plate 5 without being refracted by the light-transmitting surface 6a (that is, the angle of refraction is 0°).

As a result, light from the illumination source unit 2 that has passed the light path adjustable plate 5 is concentrated in a specific area on the surface opposite the illumination device 10. That is, by gathering the light from the illumination source unit 2 through the light path adjustable plate 5, this illumination device 10 can illuminate the printed circuit board 14 and mark 9 thereon with an appropriate amount of light when positioned opposite the illumination device 10 on the optical axis of the CCD camera 11 (see Fig.2). In addition, because the light path adjustable plate 5 is disposed proximally to the

illumination source unit 2 in this preferred embodiment, light from light sources 3 of a specific number or quantity of light can be efficiently picked up and concentrated on the mark 9.

It is therefore possible with an illumination device 10 according to this preferred embodiment of the invention to expose a mark 9 on the printed circuit board 14 with an amount of light suitable to object recognition without increasing the number of light sources or the output of each light source, and without requiring a complicated construction for adjusting the path of the illumination light.

It should also be noted that a specific illumination control means (not shown in the Figs.) can be provided for this illumination device 10 to adjust the output of the light sources 3 or turn on only part of the light sources 3 in the illumination source unit 2 opposing the light path adjustable plate 5 according to the surface condition of the printed circuit board 14 and the mark 9 thereon. Fig.7A and Fig.7B are descriptive section views of an illumination device 10 in which part of the light sources 3 are selectively turned on according to different surface conditions.

On condition that the surface of the mark 9 is a mirror surface, such as condition that a mark 9 on a ceramic printed circuit board 14 is coated with solder, when

light is emitted from a direction at an obtuse angle to the optical axis of the CCD camera 11(see Fig.2), the illumination light will be totally reflected with substantially no light entering the CCD camera 11. In this case, therefore, only the light sources 3 belonging to the light source group 3A (see Fig.4) at the inside-most circumference are turned on so that the illumination light is totally reflected at the surface of the mark 9 and picked up by the CCD camera 11 as shown in Fig.7A.

Furthermore, on condition that the surface of the printed circuit board 14 is a near-mirror surface, such as condition that a copper mark is formed on a printed circuit board made from glass epoxy, only the light sources 3 belonging to the light source groups 3C and 3D (see Fig.4) at the outside circumference are turned on as shown in Fig.7B. In this case, the light incident to the printed circuit board 14 is totally reflected, and substantially no light enters the CCD camera 11. On the other hand, light incident to the mark 9 is randomly reflected, and part of the light enters the CCD camera 11. As a result, the mark 9 is seen brighter than the printed circuit board 14 in the background.

By thus selectively turning on the light sources 3 of the illumination source unit 2 to emphasize the contrast between a mark 9 and the background printed circuit board

14 according to the surface condition of the printed circuit board 14 and mark formed thereon, an even clearer image can be obtained by the CCD camera 11, and the accuracy of mark 9 recognition by the apparatus can be improved.

Yet further, the emission side of the light path adjustable plate 5 is divided into three subareas 6, 7, and 8 in this preferred embodiment, but the present invention shall not be so limited. For example, the emission side of the light path adjustable plate 5 can be divided into only two or more than three subareas. In particular, when divided into more than three subareas, light from the illumination source unit can be even more efficiently concentrated on the object, such as the printed circuit board and mark by setting a different angle of refraction for the light-transmitting surface of each subarea so that light from the illumination source unit is refracted at a different angle of refraction at each light-transmitting surface. As a result, appropriate illumination light can be emitted for object recognition.

An alteration of the light path adjustable plate is shown in Fig.8. This light path adjustable plate 25 comprises a plurality of subareas 26 formed in concentric circles. The light-transmitting surface 26a of each subarea 26 is a segment of a curved surface with the curvature thereof differing in each subarea 26. The refractive index of

each subarea 26 decreases as it is closer to the center. When a light path adjustable plate 25 thus comprised is used, light from the illumination source unit is refracted at each point of each light-transmitting surface 26a so that it is directed toward the object, such as the printed circuit board and mark. As a result, light from the illumination source unit can be minutely concentrated on the printed circuit board and mark.

A further alternative version of the light path adjustable plate is shown in Fig.9. With this light path adjustable plate 27, both the light incidence and emission sides of the light path adjustable plate 27 are divided into belt-shaped subareas 28, 29, and 30 forming concentric circles. Each of these subareas has a light-transmitting surface 28a, 29a, and 30a, each having a different curvature. Among them, light-transmitting surfaces 29a and 30a being a segment of a convex curve. The refractive index of each subarea 28, 29, and 30 decreases as it is closer to the center. The light gathering effect of this light path adjustable plate 27 is greater than that of a light path adjustable plate having subareas formed on only one side of the plate, and can more efficiently concentrate light on the printed circuit board and mark.

Though not specifically shown in the figure, the light-transmitting surfaces of this light path adjustable plate

can be processed to a pear-skin surface (that is, a rough ground glass surface). In this case, light from the illumination source unit can be emitted to a specific area including the object while diffusing the light to the extent that the light gathering effect of each light-transmitting surface having a specific refractive index is maintained.

It should be further noted that while the above-noted preferred embodiments are described using white LEDs as the light sources 3 of the illumination source unit 2, the present invention shall not be so limited. For example, a light source such as an LED that emits any of the colors red, green, and blue can be used. Fig.10 shows an illumination source unit 42 comprising such a light source.

In this illumination source unit 42, the light sources 43 are arranged in concentric circles with each light source 43 containing LEDs capable of emitting red, green, or blue. The illumination source unit 42 can produce light with the color composed of RGB with brightness and chroma adjusted by controlling the current supplied to each light source 43. As a result, the illumination source unit 42 can emit light in a plurality of colors.

For example, when the recognition mark is on a green printed circuit board, it is therefore possible using an illumination source unit 42 thus comprised to emit "red" light, that is, the light with the color complementary to

green (that is, to turn only the red light sources on), and thereby darken the printed circuit board, which forms the background of the mark. Insofar as the mark is not greenish, the "red" light illuminating the mark will be picked up by the CCD camera, and an even clearer image with emphasized contrast between the printed circuit board and mark can be obtained.

Furthermore, on condition that the mark on the printed circuit board is red, for example, it is likewise possible in this embodiment to turn on the green and blue light sources, control the current supply to each light source to produce "blue-green" light, that is, the light with the color complementary to red, and thus darken the printed circuit board forming the background to the mark.

It is also possible to emphasize the contrast between the printed circuit board and mark by forming the color complementary to the color of the mark and thereby darken the mark. For example, if a mark is made with yellow adhesive on a white printed circuit board, it is possible to turn on the red and blue light sources of the illumination source unit 42 and control the current supply to the light sources to form a bluish-violet light, that is, the light with the color complementary to yellow. As a result, the mark is darkened, while the bluish-violet illumination emitted to the printed circuit board is picked up by the CCD

camera, resulting in the contrast between the printed circuit board and mark being enhanced.

As thus described, it is possible with an illumination source unit 42 comprising, for example, RGB light sources 43, to produce the color complementary to the color of the printed circuit board or mark by controlling the current supply to the light sources 43, and thereby enhance the contrast between the printed circuit board and mark. As a result, the CCD camera can capture an even clearer image, and the accuracy of mark recognition by the apparatus can be improved.

The illumination source unit can further alternatively comprise a light source capable of emitting a plurality of colors, such as a 3-in-1 type LED, as a light source for producing the color complementary to the color of the printed circuit board or mark. This 3-in-1 LED contains an RGB three color LED, and can alone emit light in a plurality of colors by controlling the current for each color to adjust the brightness and chroma.

Fig.11 is a circuit diagram showing an exemplary illumination circuit containing such a 3-in-1 LED. The plural 3-in-1 LEDs provided in this illumination circuit 45 are composed of RGB LEDs arranged in a row by color. In this circuit 45, all of 3-in-1 LEDs are connected in series. The current flow to these 3-in-1 LEDs 47 is controlled for each

color of LED by an illumination controller 49 in this illumination circuit 45. With an illumination circuit 45 in which LEDs are connected in series as noted above, power consumption is relatively low.

With an illumination source unit 40 as shown in Fig.10, each light source 43 emits only one color, red, green, or blue, and different colors of light from the light sources 43 mix on the printed circuit board and mark to form a complementary color. This can result in color irregularities or a rainbow of colors reflecting from the surface of the printed circuit board or mark, on condition that the surface of the printed circuit board or mark is uneven, for example, because different colors emitted from different angles thus reflect at correspondingly different angles.

With an illumination source unit comprising 3-in-1 LED 47 light sources, each light source can be driven to emit light already adjusted to the color complementary to the color of the printed circuit board or mark. Illumination with no color irregularities can thus be emitted, and, as a result, the contrast between the printed circuit board and mark can be reliably emphasized according to the surface condition of the printed circuit board or mark.

Furthermore, with an illumination source unit having a 3-in-1 LED 47 as described above, it is not

necessary to provide a light source for each color, relatively few light sources are needed, and reduction in the size and weight of the illumination source unit can be promoted.

In the above-described embodiments of the invention, a fluorescent light or light bulb can also be used as the light source of the illumination source unit. The light source can also be one emitting light with different colors or wavelengths. In selecting this light source, it is also possible to select a light source with the color or wavelength suitable to the surface condition of the printed circuit board or mark thereon so that the CCD camera can capture a clear image.

Yet further, when a filter is disposed between the illumination source unit and the object, such as the printed circuit board and mark, for the purpose of obtaining illumination light with a desired color or wavelength, for example, this filter can be processed for use together with the light path adjustable member.

The invention has been described in detail with particular reference to certain preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the sprit and scope of the invention.

CLAIMS

1. An electronic component mounting apparatus for recognizing a mark provided at a specific location on a printed circuit board, and mounting an electronic component on said printed circuit board, said mounting apparatus comprising as a device for illuminating said mark:

an illumination device having a light path adjustable member where at least either the light incidence side or emission side thereof is divided into a plurality of subareas with respective different index of refraction, the light path adjustable member being disposed between an object to be illuminated by the emitted light and an illumination source unit for emitting light in the direction of said object,

wherein the light path adjustable member gathers light emitted therefrom on a specific area including said object by emitting light incident thereto from the illumination source unit from each of the subareas at the respective different index of refraction.

2. The electronic component mounting apparatus as set forth in claim 1, wherein at least either the light incidence side or emission side of the light path adjustable member is divided into a plurality of belt-shaped subarea forming concentric circles, and the index of refraction on

the emission side of each belt-shaped subarea decreases as it is closer to the center.

3. The electronic component mounting apparatus as set forth in claim 1 or 2, wherein the light-transmitting surface of a plurality of the subareas in the light path adjustable member is a segment of a curved surface, the curvature of which differs in each subarea.

4. The electronic component mounting apparatus as set forth in claim 3, wherein both the light incidence side and emission side of the light path adjustable member are divided into a plurality of subareas, each having a different index of refraction, and both light-transmitting surfaces of each subarea are segments of a convex curved surface.

5. The electronic component mounting apparatus as set forth in any of claims 1 to 4, wherein the light-emitting surface of each subarea is formed in the shape of a ground glass surface.

6. The electronic component mounting apparatus as set forth in any of claims 1 to 5, wherein the illumination source unit comprises a plurality of light sources directed toward each subarea of the light path adjustable member,

and said light sources can be selectively turned on.

7. The electronic component mounting apparatus as set forth in claim 6, wherein each of the light source can emit light of a color complementary to a color of the printed circuit board or mark thereon.

8. The electronic component mounting apparatus as set forth in claim 7, wherein each of the light sources comprises a plurality of light-emitting elements of different colors.

Fig.1

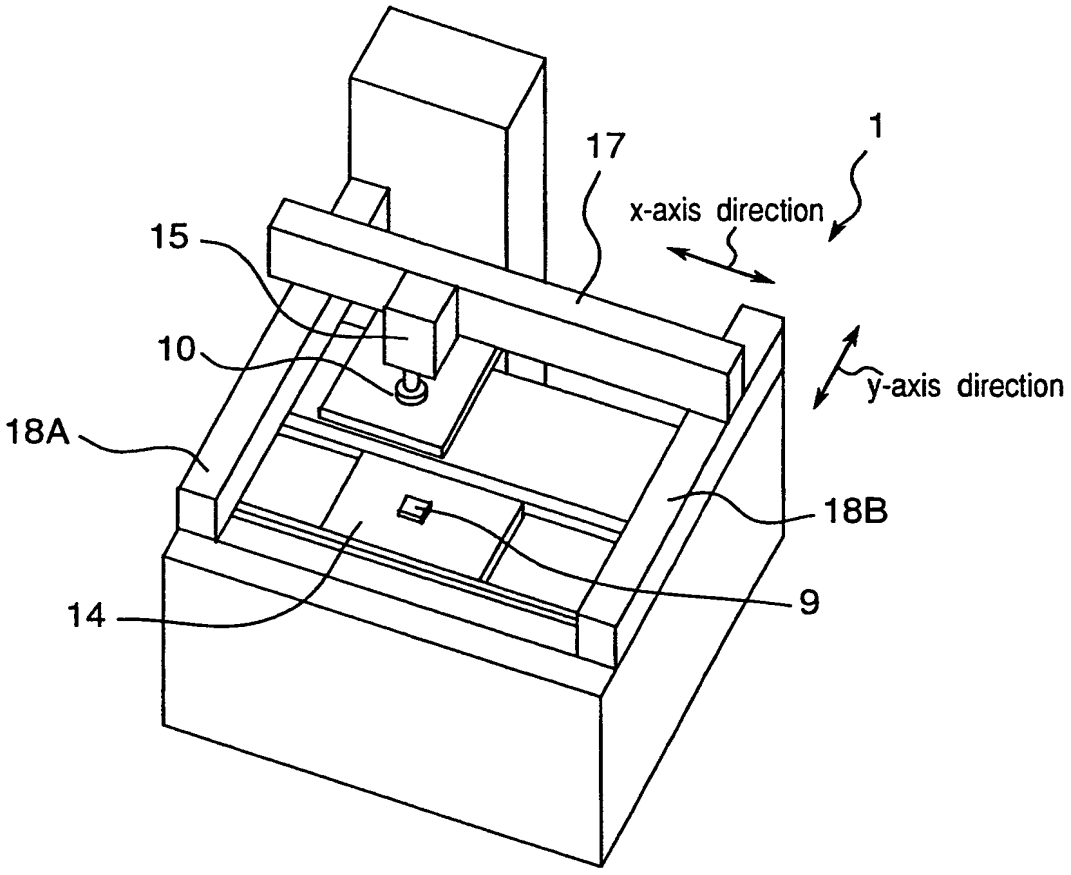


Fig.2

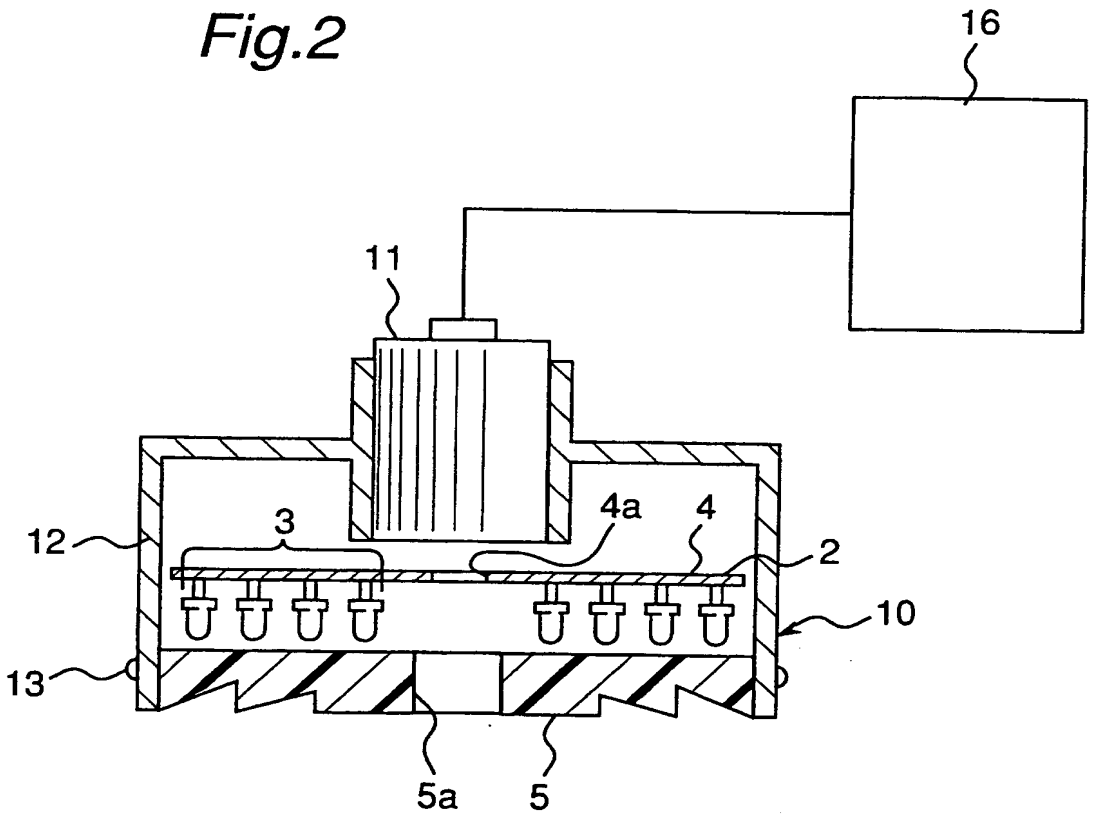


Fig.3

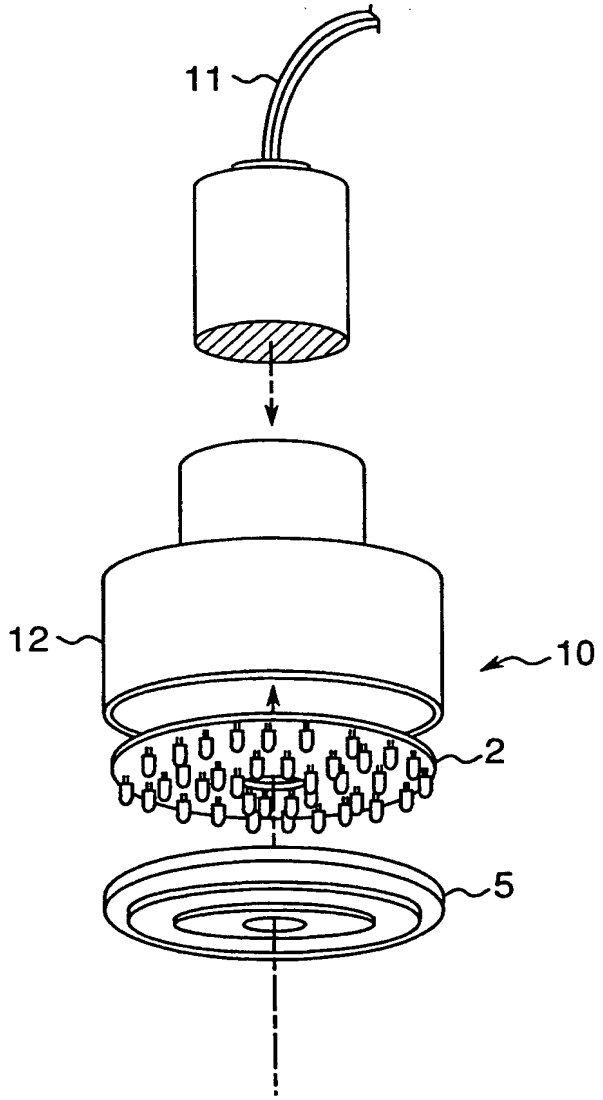


Fig.4

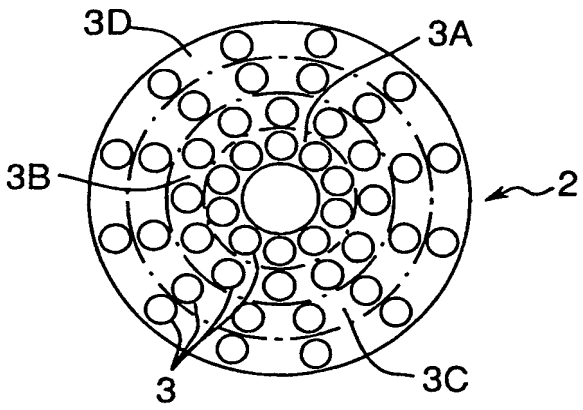


Fig.5A

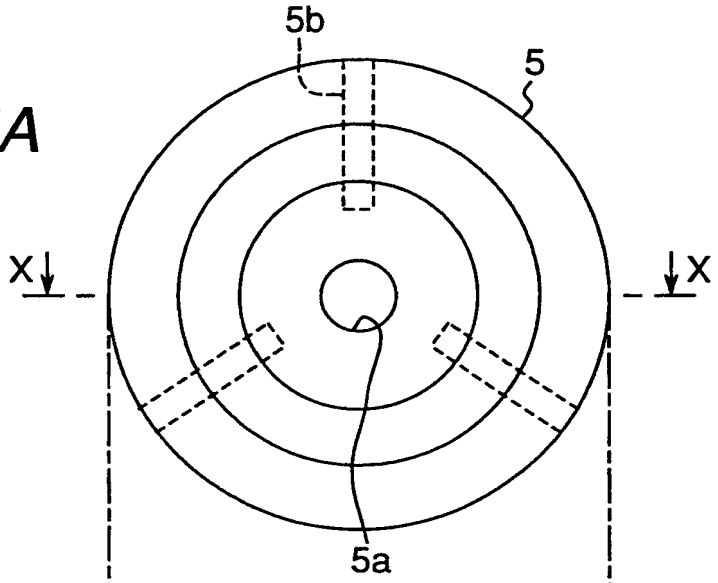


Fig.5B

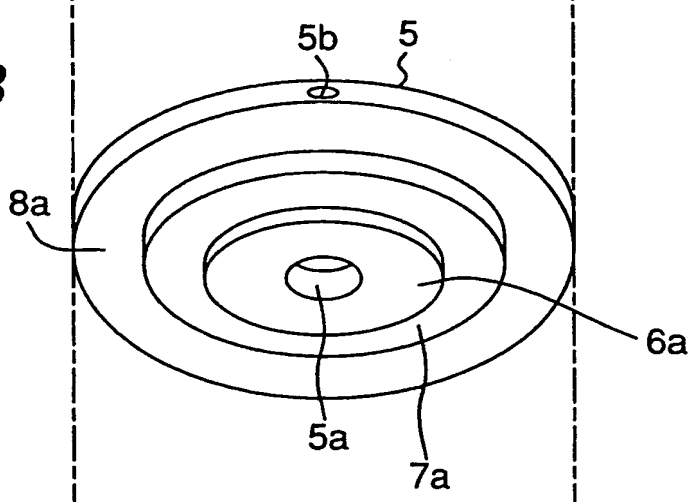


Fig.5C

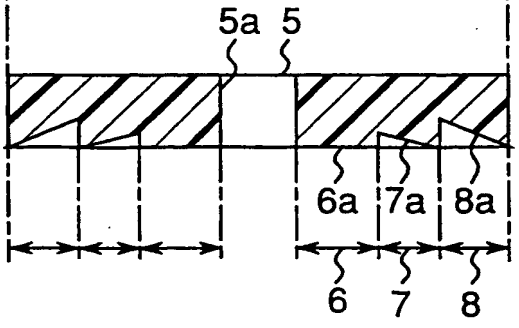


Fig.6

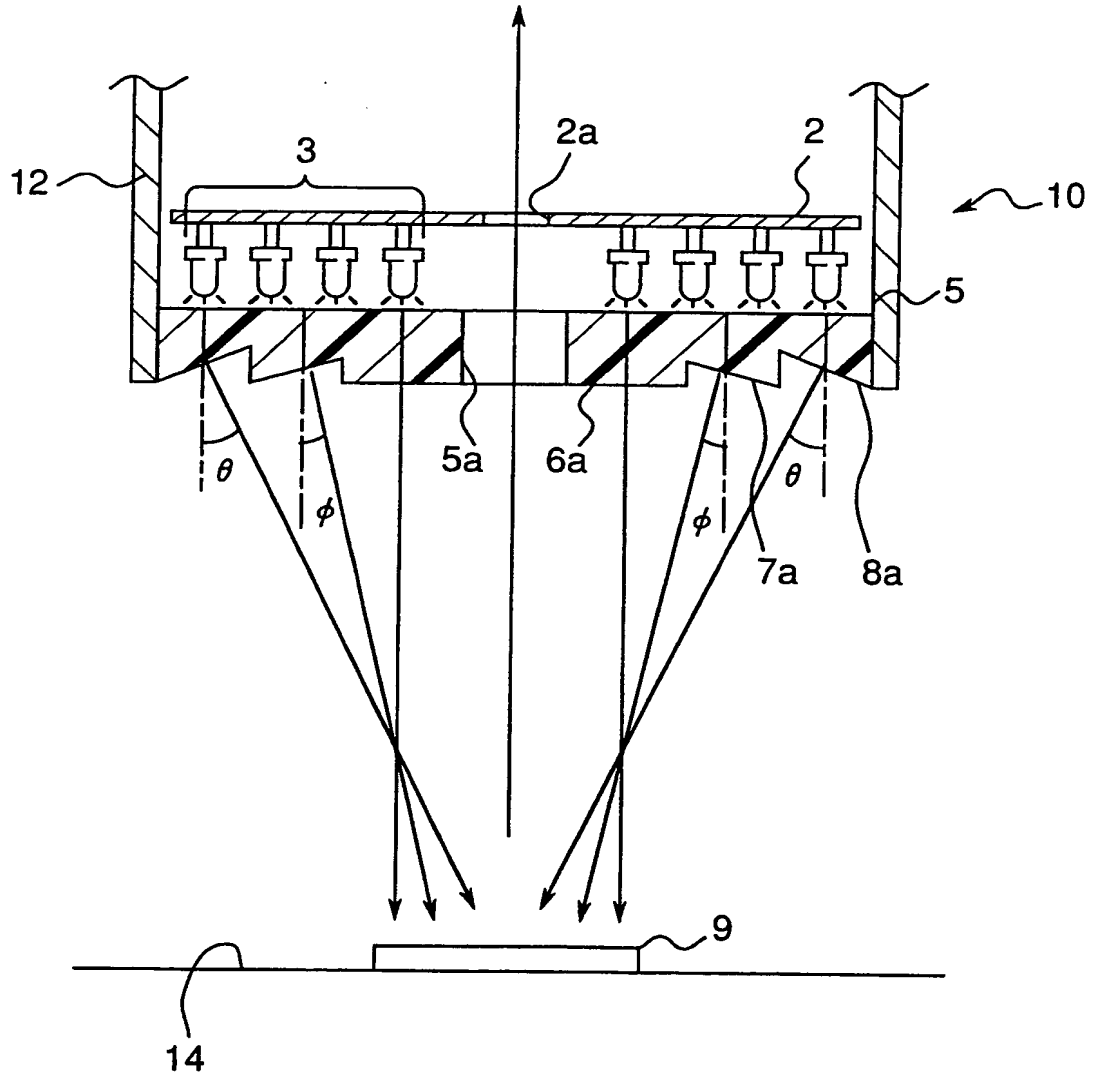


Fig.7A

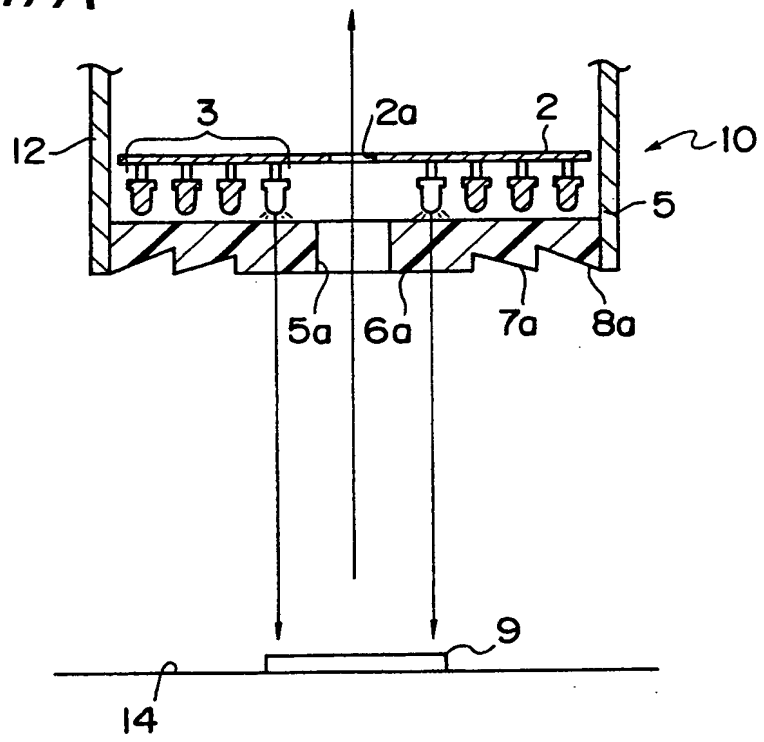


Fig.7B

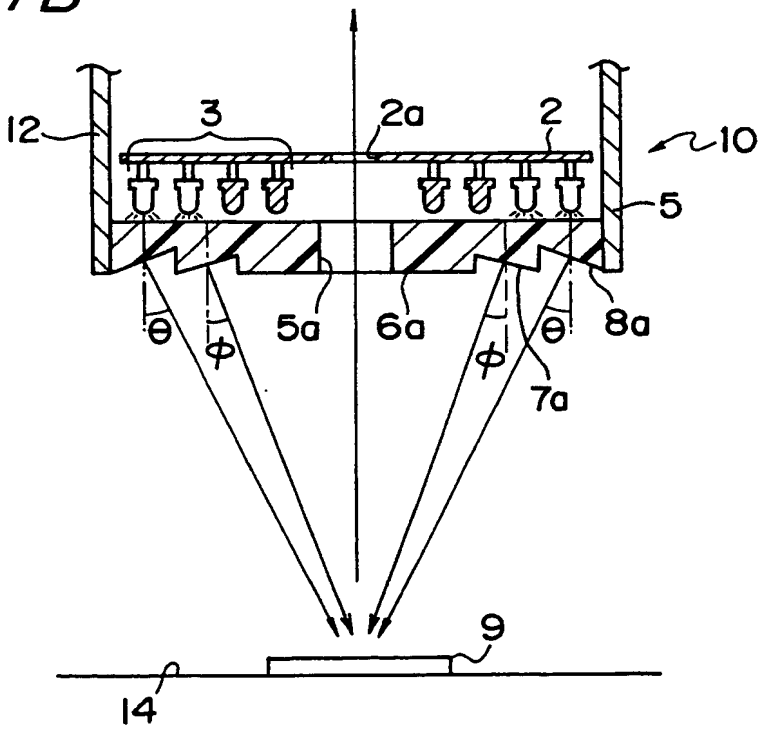


Fig.8

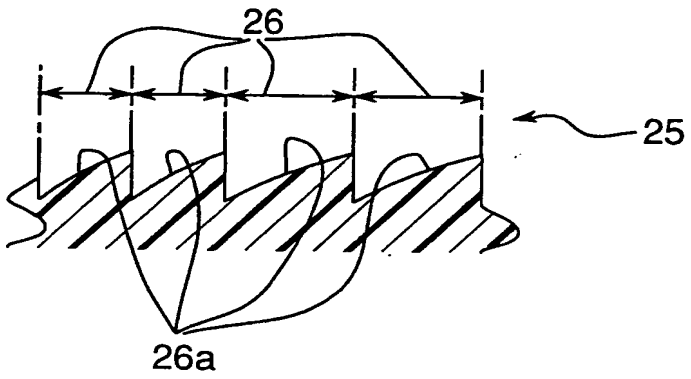


Fig.9

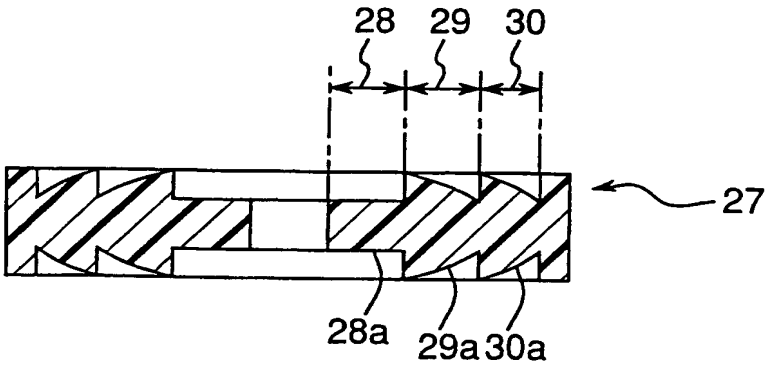


Fig. 10

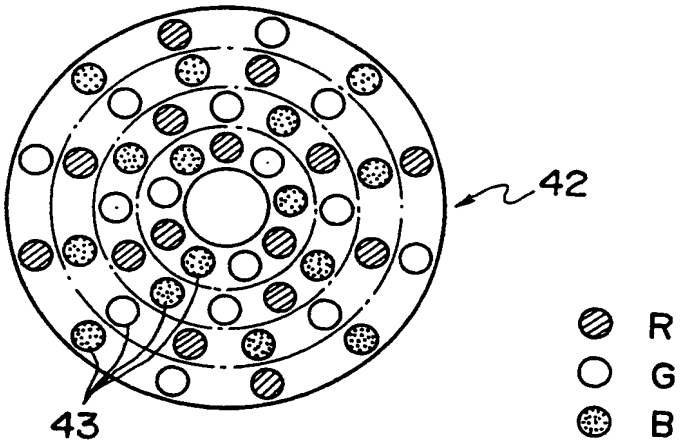


Fig.11

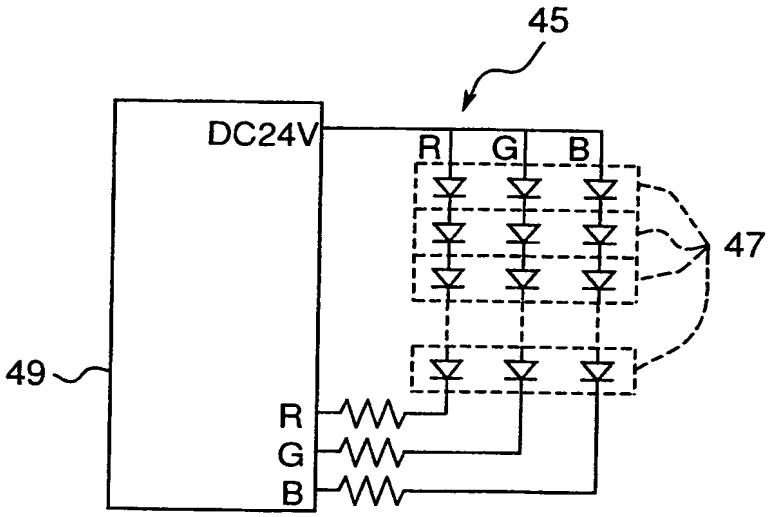


Fig.12

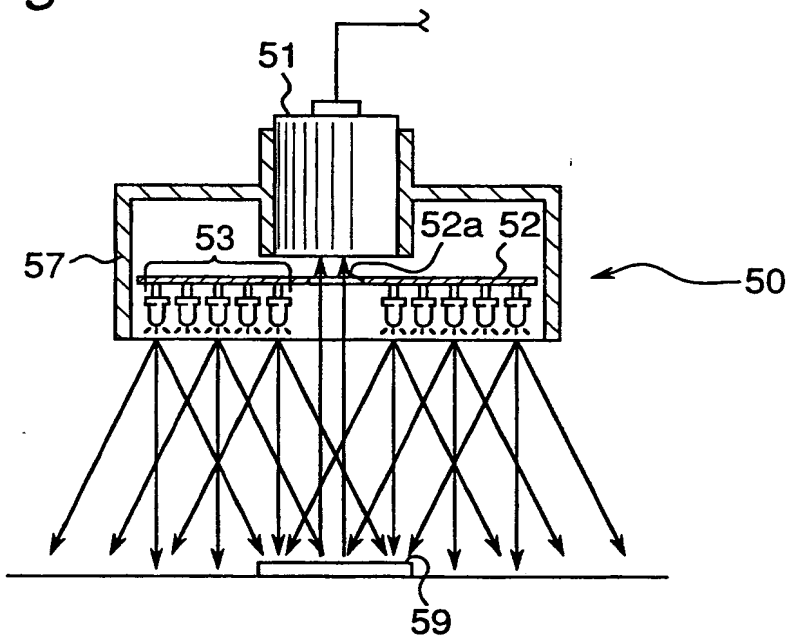
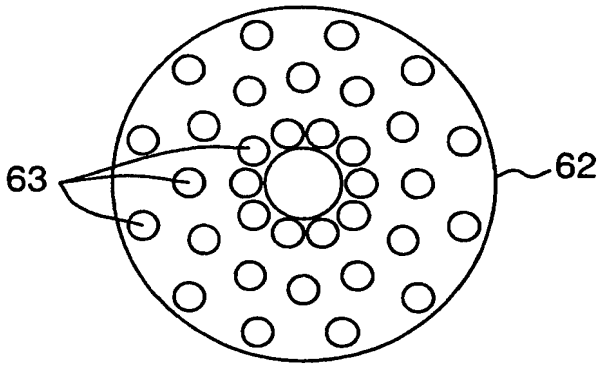


Fig.13



INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/JP 99/00904

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05K13/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05K G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	PATENT ABSTRACTS OF JAPAN vol. 98, no. 10, 31 August 1998 & JP 10 145100 A (YAMAHA MOTOR CO LTD), 29 May 1998 see abstract	1,2,6
X	PATENT ABSTRACTS OF JAPAN vol. 16, no. 378 (P-1402), 13 August 1992 & JP 04 122840 A (MATSUSHITA ELECTRIC IND CO LTD), 23 April 1992 see abstract	1-3,5
A	PATENT ABSTRACTS OF JAPAN vol. 97, no. 9, 30 September 1997 & JP 09 116297 A (YAMAHA MOTOR CO LTD), 2 May 1997 see abstract	1,5

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[X] Further documents are listed in the continuation of box C.

[ ] Patent family members are listed in annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May 1999	27/05/1999

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/JP 99/00904

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category '	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 98, no. 4, 31 March 1998 & JP 09 321494 A (YAMAHA MOTOR CO LTD), 12 December 1997 see abstract -----	1

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